STATUS OF MINERAL RESOURCE INFORMATION FOR THE HUALAPAI INDIAN RESERVATION, ARIZONA

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SUMMARY AND CONCLUSIONS

Metallic resources on the Hualapai Reservation include copper and possibly vanadium; some copper ore has been produced from one mine and very limited amounts from several prospect pits. Vanadium is found with small, low grade uranium occurrences. Nonmetallic mineral resources include limestone, sandstone, gypsum, travertine, and possibly fluorite; limestone has the greatest potential for commercial production.

Private companies are exploring for uranium deposits. Potential of nonmetallic mineral resources will be contingent on the development of markets.

INTRODUCTION

This report was prepared for the U.S. Bureau of Indian Affairs by the U.S. Geological Survey and the U.S. Bureau of Mines under an agreement to compile and summarize available information on the geology, mineral resources, and potential for economic development of certain Indian lands. Source material included published and unpublished reports, and personal communications with exploration companies active in the area and with tribal individuals.

The Hualapai Indian Reservation (Figure 1) is about 40 miles east of Kingman and 75 miles west of Flagstaff. Roughly one half of the reservation is in Mohave County and one half in Coconino County. Only a few acres are in Yavapai County. The entire reservation encompasses an area of 992, 463 acres and has a 1976 population of 1,133. In addition to the main reservation, two small areas, both in Mohave County, are part of the reservation. One of 800 acres is at Valentine about 18 miles southwest of Peach Springs (Figure 1) and is the site of the Truxton-Canyon Indian Agency. The other, called the Big Sandy area (not shown on Figure 1), includes 710 acres in T. 18 N., R. 13 W., and is 30 to 35 miles south of the Truxton-Canyon Agency. All land and mineral rights within the reservation are tribally owned except 650 acres of allotted land in the Big Sandy area. Private land within the reservation is limited to Santa Fe Railroad right-of-way and 160 acres of Santa Fe land around a well in secs. 2 and 3, T. 25 N., R. 11 W., south of Peach Springs, the main Hualapai village.

The reservation is along the south rim of the Grand Canyon, west of Grand Canyon National Park (Figure 1), an area of outstanding scenic attraction. It is bounded on the north by Grand Canyon National Monument and Lake Mead National Recreation Area. Much of the southern part of the reservation is relatively featureless but the topographic relief is great and the scenery spectacular at the canyon rim. Maximum relief on Indian land is about 5,200 feet between the Colorado River and the canyon rim in the easternmost part of the reservation.

Most of the southern and western part of the reservation is covered with juniper, pinon, and scrub oak. The northeastern part of the area is forested by pine timber and is logged periodically.

Access to the reservation is by U.S. Highway 66 and the Santa Fe Railroad, both of which pass through Peach Springs near the southern boundary. BIA roads afford access to the north, east, and west.

Principal towns of the region are Peach Springs (pop. approx. 600, BIA personal communication), Kingman (pop. 7,312), and Flagstaff (pop. 26,117). Phoenix, with an area population of 863,357, is about 280 miles to the southeast.

PHYSIOGRAPHY

Most of the Reservation is on the Hualapai Plateau, a major feature on the southwestern edge of the Colorado Plateaus physiographic province (Figure 2). The eastern one-third of the reservation lies on the Coconino Plateau, a similar but higher topographic feature. Cliffs and steep slopes of the Grand Canyon form the northern part of the reservation along the Colorado River. The relief between the Colorado River and the Hualapai Plateau surface is about 3,000 feet and about 5,200 feet between that river and the Coconino Plateau. The average elevation of the broad, flat divides on the central Haulapai Plateau near the river of the Grand Canyon ranges between 4,600 and 5,200 feet above sea level. The altitude increases slightly toward the southwest along the Lower Grand Wash Cliffs with a maximum of 6,761 feet at Music Mountain. East of the Hurricane fault the elevations increase to the Coconino Plateau which lies between 6,000 and 7,000 feet above sea level. The Aubrey Cliffs are a conspicuous scarp trending generally north-south near the western edge of the Coconino Plateau. Major canyons are in the northern part of the reservation where the streams cut deeply into the Hualapai or Coconino Plateaus to join the Colorado River at grade. Quartermaster, Meriwhitica, and Spencer Canyons are important tributaries in the western reservation; Peach Springs and Diamond Creek in the central part and Prospect Valley, Mohawk, and National Canyons are the largest and longest tributaries in the eastern part of the reservation.

PRESENT STUDY AND ACKNOWLEDGMENTS

The general regional geology was summarized from the State Geologic Map of Arizona published by the Arizona Bureau of Mines and the U.S. Geological Survey in 1969, and from the Geologic Investigations section of the National Aeronautics and Space Administration Technical Report 32-1597 published in 1975. Location and some description of mineral deposits are found on a number of Arizona Bureau of Mines maps, U.S. Geological Survey Mineral Resource Maps, U.S. Geological Survey Bulletins and CRIB files.

R. W. Schnabel and M. C. Johnson, USGS assisted in the collation of information on mines, prospects, and mineral deposits. R. A. Young of the Geology Department, New York State College, Geneseo, N.Y., loaned unpublished geologic maps of the reservation.

MAPS

The Hualapai Reservation lies within the boundaries of the U.S. Geological Survey and U.S. Army Map Service 1:250,000 scale topographic maps: Williams Sheet (NI-12-1) and Grand Canyon Sheet (NJ-12-10). More detailed, larger scale 7 ½° topographic sheets by the U.S. Geological Survey are available for the western four-fifths of the reservation (Figure 3)

Another useful source of maps for the reservation is the Bureau of Land Management, which has available land status master title plats, accompanied by an historical index. Both the plats and historical indexes may be ordered from the U.S. Bureau of Land Management, 2400 Valley Bank Center, Phoenix, Ariz., 85073; and should be designated by township and range.

The Arizona Department of Transportation publishes County road maps of the reservation. The Coconino County map is now available, and a Mohave County map is in preparation. Requests should be addressed to the Arizona Department of Transportation, General Services Group, 206 S. 17th Ave., Phoenix, Ariz., 85007. The Arizona Department of Natural Resources in Phoenix may also have pertinent map information.

Partial aerial photographic coverage of the reservation is available from the U.S. Geological Survey NCIC-W, 345 Middlefield Road, Menlo Park, Calif., 94025. Satellite imagery can be obtained from the U.S. Geological Survey, EROS Data Center, Sioux Falls, S. Dak.

GEOLOGY

Previous Geologic Investigations

J. S. Newberry of the Ives Expedition in 1861 crossed the Hualapai Valley and traveled through Truxton Canyon (approximate location of U.S. route 66) descending to the Colorado River through Peach Springs Canyon. He left the Colorado River by Diamond Creek and arrived on the Coconino Plateau. Newberry was the first to describe the physiography and stratigraphy along this route.

Other early references to the geology of the Hualapai Plateau or related areas are by: Marvine (1875), Lee (1908), Schrader (1909), and Darton (1910, 1915).

More recent studies that deal specifically with Cenozoic deposits on or near the reservation are by Koons (1948a, b), Gray (1959), and Young (1966).

There are two detailed geologic maps of the region including all or most of the Hualapai Reservation. The first is with a report by F. R. Twenter (1962); the second is with the report by Young (1966). The generalized geologic map used in this report (Figure 4) is from the Geologic map of Arizona, scale 1:500,000, published in 1969. A generalized stratigraphic section is shown in Figure 5.

Stratigraphy

General

Pre-Cenozoic stratified rocks of the Hualapai Reservation belong to the classic Grand Canyon section studied and described by many geologists. This sequence of rocks appears in nearly every elementary text book on geology and is well known throughout the world. For more detailed descriptions, correlations, and interpretations of these formations consult McKee (1945, 1969, 1974, 1975), McNair (1951), Twenter (1962), and McKee and Gutschick (1969), and references cited therein.

Precambrian

Crystalline rocks comprised of varieties of granite, gneiss, and schist crop out in the bottom of the Grand Canyon and its major tributaries. These rocks were intruded by a complex of Precambrian dikes of pegmatite, granite, and diorite. The crystalline rocks in the Grand Canyon east of the Hualapai Reservation have had various formational names applied to them such as Vishnu Schist, Brahma Schist and Zoroaster Granite. The rocks within the reservation are similar and most likely correlative with these units or at least have undergone a similar history of metamorphism and uplift. The Vishnu Schist has been dated by radiometric means as about 1.7 b.y. (billion years old) (Pasteels and Silver, 1966).

Cambrian

General.--There are three formations of Cambrian age in the western part of the Grand Canyon. These are transgressive marine strata (sediments deposited as the sea encroached on the land) of the Tapeats Sandstone, Bright Angel Shale, and Muav Limestone. The Tapeats Sandstone, which is the basal unit in this region lies on an unconformable surface that represents about 1 billion years of time. In this interval of time several periods of uplift, erosion and deposition took place, the final episode being erosion that stripped younger Precambrian strata (the Grand Canyon Series) from the surface of the older Precambrian crystalline rocks.

Tapeats Sandstone.--The basal unit of the Cambrian is composed of quartz sandstone and quartz pebble conglomerate. The formation is about 200 feet thick and forms a cliff and a steep scarp. The lower cliff-forming part is brown and gray thick-bedded coarse- to medium-grained sandstone. Crossbedding is common in this interval. The upper slope-forming part of the formation is medium- to thin-bedded, fine- to medium-grained sandstone.

Bright Angel Shale.--This Middle Cambrian formation consists of shale and some dolomite or dolomitic limestone. It is generally shades of green or reddish brown and erodes to form a slope. The formation is 325 feet thick near Bridge Canyon and is thicker to the northwest. The shales in the Bright Angel are important as impermeable horizons that control the movement of ground water.

Muav Limestone.--Upper Cambrian rocks are included in the Muav Limestone which is mostly dark-gray thin-bedded limestone and dolomite. Near the base of the formation the limestone beds alternate with thin reddish or yellowish limey siltstone. The upper part is massive, mottled dolomite and limestone. The formation has an average thickness of about 700 feet and erodes into two cliffs separated by a slope.

Devonian

Cliff-forming limestone of Devonian age lies unconformably on the Muav Limestone. These unnamed limestones (correlative with Temple Butte Limestone) are light yellow, brown, and olive gray and in places are dolomitic with zones of gray chert nodules. In the western Grand Canyon (Hualapai Reservation) the Devonian limestones are about 375 feet thick; they thicken to the northwest and thin to the east.

Mississippian

Redwall Limestone.--This formation crops out as a conspicuous cliff, locally cavernous, more than 550 feet high midway in the stratified sequence in the region of the Hualapai Reservation. It lies unconformably on the Devonian limestone in the western part of the Grand Canyon. This limestone unit is aphanitic to coarsely crystalline, contains thin beds, stringers, and blebs of dark chert and is generally light gray. In places it is richly fossiliferous and contains zones made up almost entirely of crinoid debris. It has been divided into four members (McKee and Gutschick, 1969).

Pennsylvanian and Permian

Rocks of Pennsylvanian and Permian age are included in the Supai Group and have been named, in ascending order, Watahomigi Formation, Manakacha Formation, Wescogami Formation, and Esplanade Sandstone (McKee, 1975). The Supai Group is overlain by the Hermit Shale of Permian age. In the Hualapai Plateau only the lower formation of the Supai Group remains as the cap of the plateau. On the Coconino Plateau to the east the upper formations of the Supai Group as well as the Hermit Shale are preserved.

The Supai Group is comprised mostly of limey sandstone, sandy and silty limestone and siltstone. The entire group is characterized by reddish hues although there are many gray- and olive-colored rocks. The Watahomigi Formation at the bottom of the group lies unconformably on the Mississippian Redwall Limestone. It is thin-bedded gray limestone and red-brown siltstone and is about 300 feet in Prospect Canyon and thickens to the northwest. The upper three formations of the Supai Group are mostly sandstone and limestone with the top formation, the Esplanade Sandstone, forming a conspicuous cliff as its name implies. The combined thickness of the three upper formations of the Supai Group is more than 1,000 feet.

Permian

Hermit Shale.--Gradationally above the Supai is the Hermit Shale, a red-brown thin-bedded fine-grained silty sandstone. The formation is easily eroded, hence forms a slope locally capped by resistant formations. It occurs only in the eastern part of the Coconino Plateau where it is about 930 feet thick.

Coconino Sandstone.--This formation crops out only in the eastern part of the reservation where it unconformably overlies the Hermit Shale. It is a fine-grained light-colored weakly cemented sandstone, typically crossbedded. The sand grains are mostly moderately rounded quartz and the unit is well sorted. In the vicinity of Blue Mountain Canyon it is about 270 feet thick; it thins to the north and west to about 100 feet near the mouth of Prospect Canyon.

Toroweap Formation.--The Toroweap Formation of the eastern part of the reservation consists of two distinctive rock units; the upper is gypsum-rich shale and massive gypsum that forms a slope, the lower is a cliff formed of cherty limestone, sandstone, siltstone, and gypsum. The shale and mudstone beds in the formation are red and on weathering tend to color the entire formation and underlying rocks red. The thickness of the Toroweap in the western part of the Coconino Plateau is about 350 feet.

Kaibab Limestone.--The youngest Paleozoic formation in the Hualapai Reservation is the Kaibab Limestone, which forms most of the Coconino Plateau. This cliff-forming unit is a light- to dark-gray cherty limestone that contains solution cavities, sinkholes, and caverns. The formation is about 260 feet thick near the mouth of Prospect Canyon.

Triassic

Moenkopi Formation.--Triassic strata represented by the Moenkopi Formation crop out in a small area near Frazier Well in the eastern part of the reservation. The Moenkopi rests unconformably on the Kaibab Limestone and contrasts with that formation in consisting mostly of red beds of mudstone, siltstone, sandstone, and limey and gypsiferous sandstone. Because the upper part is eroded, only a partial thickness remains.

Cenozoic

Cenozoic rocks crop out in two separated parts of the Hualapai Reservation: on the Coconino Plateau in the vicinity of Frazier Well and south of the "big bend" in the Colorado River in Milkweed, Hindu, and Lost Man Canyons, as far south as Peach Springs and Truxton.

The Cenozoic rocks in the eastern part are partly unconsolidated to unconsolidated gravel beds, some containing as much as 60 percent sand, silt, or clay (Koons, 1948a, b). Most of the pebbles are well-rounded pieces of granite, gneiss, schist, quartzite, limestone, and sandstone typical of the Precambrian and Paleozoic rocks of the region. These gravel beds were deposited in ancient stream channels cut in the Triassic and Permian rocks that now form the highest part of the Coconino Plateau. The source of the gravel was south of the present plateau and the ancient drainage system flowed from central Arizona into northern Arizona in a direction opposite to the present drainage. The age of these gravels is not known precisely but basalt flows that cover them east of the reservation are as old as 14.0±0.6 m.y. (McKee and McKee, 1972) so that the gravels must be at least slightly older.

Cenozoic rocks in the central and western part of the reservation are thick and lenticular deposits of poorly sorted sedimentary rocks that represent detritus that accumulated in local, rapidly developing basins (Young, 1966). The exposures at Milkweed Canyon (Figure 6) are more than 1,000 feet thick; in Peach Springs Canyon about 1,200 feet of Cenozoic rock can be measured in composite sections, and in Hindu Canyon a section of comparable thickness is exposed. Because of the very lenticular nature of these conglomeratic rocks it is impossible to match the sections in detail. In general the lower half or more of the section is weakly cemented arkosic sandstone and interbeds of conglomerate locally containing clasts of more than 36 inches in diameter. The pebbles, cobbles, and boulders are mostly Precambrian rock types such as granite, gneiss, and metadiorite. Formational names applied to these rocks by Young (1966) include the Music Mountain Conglomerate, Hindu Fanglomerate, Westwater Formation, and Buck and Doe Conglomerate and Willow Springs Formation (see Figure 6). The upper one-half to one quarter of the Cenozoic sequence is mostly volcanic rock--ash flows, lava flows, and agglomerates. These are informally named the Hualapai volcanics by Young (1966). The lavas which represent local eruptions range in composition from dacite to basalt; they are commonly the youngest rock at a given locality. The Peach Springs Tuff, a distinctive welded ash-flow sheet of regional distribution is part of many of the sequences and serves as a marker and datum. This welded tuff has been dated by K-Ar at 18.3±0.6 m.y. (Damon, 1964, p. 20) which suggests it is middle Miocene in age. The thick, lenticular sequences of predominantly coarse clastic rock beneath the Peach Springs Tuff are probably not a great deal older than the tuff; most likely they are early Miocene.

Structure

Strata in the Hualapai Reservation are almost completely undeformed, although they, like other parts of the Colorado Plateau, have been uplifted many thousands of feet from their original site of deposition. Except for small faults and large slump or landslide features there are only five structures of significant size within the reservation. These are the Meriwitica fault and monocline, Hurricane fault, Peach Springs monocline, Toroweap fault, and Mohawk fault. All the major faults (with the exception of the Meriwitica) and most of the minor ones are normal and northeast trending with the western side downthrown.

By far the most conspicuous geologic structure on the reservation is the Hurricane fault (Figure 2) and its ancillary features. This fault crosses the central part of the reservation and has been traced many miles to the north and a few miles to the south. Most of its length in the reservation is in Peach Springs Canyon, and it is probably partially responsible for the existence of this canyon as it controlled the direction of drainage which eroded the canyon. The Hurricane fault is a normal fault downthrown to the west with displacement of about 1,300 ft where it crosses the Colorado River, becoming less to the southwest. Near the head of Peach Springs Canyon its offset is about 250 ft. Associated with this fault are many smaller faults with displacements between 800 ft and 100 ft. The largest secondary fault is in Granite Park Canyon west of the main Hurricane fault.

The Toroweap fault parallels and is about 6 miles east of the Hurricane fault. It is a high-angle normal fault with the west side downthrown. Displacement near the Colorado River is about 700 ft and in Diamond Creek about 20 miles to the south about 1,000 ft. This fault can be traced for more than 30 miles in the reservation and almost as much to the north.

A third parallel fault about 6 miles east of the Toroweap fault is in Mohawk Canyon. This fault can be traced for about 15 miles although offset is not great, being less than 100 ft in most places.

The Meriwitica fault crosses the Colorado River at Horse Flat Canyon. Here it is a north-south normal fault with small offset, the east side downthrown. Within a few miles to the south the offset is expressed as a monocline with as much as 700 ft of offset on the structure. The flexure trends south for about 5 miles, turns eastward for another five miles, and finally trends south again in Milkweed Canyon.

The Peach Springs monocline is east of the town of Peach Springs and trends northeastward for about 5 miles. The displacement on the fold is 300-400 ft.

A small dome less than a mile across in any direction but with nearly 1,000 ft of uplift occurs on the reservation boundary north of Nelson. This feature does not seem to be related to the other linear northeast-trending faults or monoclines of the reservation.

MINERAL RESOURCES

General

Known mineral resources of the Hualapai Indian Reservation include uranium, vanadium, copper, gypsum, limestone, sandstone, travertine, and sand and gravel (Figure 7). Both fluorite and manganese minerals have been reported on nearby lands, but available information does not indicate that these minerals extend on the reservation.

Energy Resources

General

Of the mineral fuels, only uranium has been discovered within or near the reservation. No occurrences of petroleum, natural gas, or coal have been noted in the area.

Uranium

General.--Geologic studies of the uranium deposits of the Colorado Plateau show that uranium occurs in lenticular bodies of sandstone usually containing abundant carbonized material, petrified wood and clay lenses and clay balls which represent filled channels. Volcanic rocks may or may not be present in the stratigraphic sequence. On the Hualapai Reservation some parts of the Pennsylvanian and Permian Supai Group and the Permian Hermit Shale are similar to host rocks in which uranium and vanadium has been found elsewhere on the Colorado Plateau. The only known occurrence is in sandstone from the Supai Group (Miller, 1954a) at the Ridenour mine, but there has been no production.

Uranium Leases.--Western Nuclear and Verde Nuclear, acting as a joint venture on the reservation, are currently (1977) exploring several leases (Figure 8). There are seven current leases and one abandoned lease. Four of the current leases are to Verde Nuclear and two to Western Nuclear. All leases except Mulberry Springs, in T. 26 N., R. 11 W., are on what is described as collapse pipe structures; no information is available concerning the Mulberry Springs lease. Current exploration activity is listed in Table 1.

Although some sandstone pipes have been known to host relatively rich deposits (Woodrow mine, Valencia Co., N. Mex., Moench and Schlee, 1967), their areal extent tends to be rather small, and they probably do not extend to great depth. Little else is known of uranium occurrences on the reservation, and further information must await results of the current exploration program.

Petroleum and natural gas

No oil or gas test holes have been drilled on the reservation. According to Pierce, Keith, and Wilt (1970), only three test holes have been drilled within 20 miles of Indian land. Two, in T. 26 N., R. 16 W., penetrated Tertiary salt and one, in T. 25 N., R. 8 W., reached the Devonian Tapeats Sandstone. Keith A. Yenne, U.S. Geological Survey, states that the Santa Fe Railroad well north of Peach Springs was drilled to a depth of 1,040 feet and stopped in Precambrian rocks. Quoting the Arizona Oil and Gas Conservation Committee, Yenne adds that owing to the lack of subsurface data the area cannot be evaluated as to oil and gas potential. The oil and gas potential of the area appears minimal owing to the proximity of the Grand Canyon where all sedimentary formations, that might have potential for hydrocarbon accumulation, have been exposed.

Table 1

Exploration activity on uranium leases on the Hualapai Indian Reservation, 1976

Lease name	Lessee	Status	Location of Activity	Structure	Exploration to 1976
Ridenour*	Western Nuclear	Current	Sec. 6, T.31N.,R.8W.	Pipe	3 holes
Mulberry Springs	do	do	Sec. 27, T.26.,R.11W.	Unknown**	10 holes
Blue Mtn.	Verde Nuclear	do	Sec. 25, T. 27N.,R.9W.	Pipe	4 holes
Prospect Valley*	do	do	Sec. 13, T.30N.,R.8W	Pipe	surface explorations
Mohawk	do	do	Sec. 6, T.32N.,R.6W.	Pipe	Do.
Prospect	do	do	Secs. 13,14, T.32N.,R.8W.	Pipe (2)	Do.
Unknown	do	Abandoned	Sec. 25,35,36, T. 30 N., R. 8 W.	Pipe (2)	Do.

*Further drilling planned during 1977.

**The structure being explored on this lease may be small channel deposits.

Metallic Mineral Resources

General

Known metallic mineral resources on the Hualapai reservation are copper and vanadium. Manganese ore has been mined near the southeast boundary, and other may occur near the northeast corner of the Indian land at Valentine.

Copper and Vanadium

Copper ore has been mined on the reservation at the Ridenour mine. Several other occurrences are known, but development has been limited to prospect pits from which there has been little or no production.

Ridenour Mine.--The Ridenour mine is about 1,420 feet below the south rim of the Grand Canyon in SE¼NE¼ sec. 6, T. 31 N., R. 8 W. (Figure 7). The deposit, discovered in the 1870's, was mined intermittently until about 1918. Total production probably did not exceed 1,000 tons of hand-picked copper ore. The ore was moved to the rim by burro, transferred to wagons, and transported to the rail head at Nelson just east of Peach Springs (Miller, 1954).

According to Miller (1954, p. 11), the deposit occurs in the Permian Supai Formation and appears to be in a slump block or zone of subsidence. Minerals in the deposit are malachite, azurite, chrysocolla, chalcocite, chalcopyrite, bornite, pyrite, limonite, carnotite, vanoxite, and volborthite. A trace of cobalt is also reported. Miller indicates that the higher grade ore is largely mined out and that, although the rocks below the mine are not well exposed, the copper-bearing fractures diminish to the east and pinch out before they reach the canyon floor about 100 feet below the mine.

The Ridenour property was also investigated by a geologist for Uranium Enterprises (date unknown) and by a consultant in 1954, and more recently, by Western Nuclear, a subsidiary of Phelps Dodge Corp.

Bureau of Land Management personnel examined the property in 1955 and concluded that the tribe now owns the property; all mineral claims to the land after January 4, 1883, were invalid.

Other Prospects.--Four other copper occurrences are known (Figure 7). Development on all four is confined to prospect pits, although it is possible that a few tons of carbonate ore was removed from the Kate Crozier property in the SE¼NE¼ sec. 36, T. 30 N., R. 8 W., and the North Laguna mine in the NW¼NE¼ sec. 32, T. 30 N., R. 7 W. The other two prospects are in the SW¼SW¼ sec. 25, T. 30 N., R. 8 W., and SW¼SE¼ sec. 26, T. 30 N., R. 8 W. One other small copper occurrence was noted by Miller (1954) as being on Hualapai land. The deposit is near the road in the northern part of T. 26 N., R. 8 W., and is a small pit containing azurite, malachite, and chrysocolla filling interstices of the Coconino sandstone.

A map of known metallic mineral occurrences (Keith, S. B., 1969) shows a copper uranium vanadium occurrence in T. 31 N., R. 9 W.

Manganese

General.--Manganese ore is not known to occur on Hualapai land. However, two occurrences are near the reservation boundary. One occurrence, the Johnson and Hayden deposit, has yielded a small tonnage of ore; the other is at the northeast corner of the small area of Indian land at Valentine and it may have yielded a very small quantity of ore.

Johnson and Hayden Deposit.--This property in NW sec. 2, T. 26 N., R. 7 W. (Figure 7), 4 miles east of the reservation, has yielded about 300 tons of hand sorted ore averaging between 24 and 28 percent manganese. Farnham and Stewart (1958, pp. 12-13) describe the deposit as follows:

> "Manganese mineralization on the property occurs within a steeply dipping fracture or brecciated zone cutting the gently dipping beds of the Kaibab limestone. The fracture zone on the surface ranges from 10 to 30 feet in width, strikes northeast, and is exposed in places along the strike for over 1,000 feet. Although manganese mineralization was evident in several places along the outcrop of the brecciated zone, the better mineralized portion appeared to be limited approxi-

mately to a strike length of 300 feet and an average width of 25 feet. The principal workings were confined to this area; they consisted of a centrally located crosscut adit with two short drifts and several pits on each side of the adit. The deepest of these openings was about 40 feet below the outcrop.

"The manganese minerals, consisting of a mixture of the common oxides, occur as irregular masses and seams distributed erratically within the brecciated and silicified limestone. The gangue, in addition to unreplaced wall-rock fragments, consisted largely of chert, calcite, and iron oxides.

"No regular procedure was followed in mining the ore; the larger and higher grade masses of manganese oxides were gouged out as they were encountered in the exploratory openings."

Although this deposit is in the Kaibab Limestone which forms the surface over a large portion of the southeastern part of the reservation, erosion has removed the Kaibab from the area between the Johnson and Hayden deposit and the reservation boundary.

Carrow Prospect.--The Carrow manganese occurrence is near the small area of Hualapai land at Valentine (Figure 3). Stipp, Haigler, Alto, and Sutherland (1967) report a manganese occurrence in sec. 2(?), T. 23 N., R. 13 W. No other information is given. Farnham and Stewart (1958, p. 56) describe the Carrow prospect in SW¼ sec. 35, T. 24 N., R. 13 W., about 2.7 miles east of Valentine. However, that section is north of Valentine, not east. Farnham and Stewart also state that this deposit is "far removed from any other known manganese deposits." Perhaps the two locations have been cited for the same deposit. The deposit is described by Farnham and Stewart as follows:

"Manganese minerals filling narrow seams are exposed in a few scattered spots in a basalt underlying a flat basin like valley. During the Second World War shallow pits were dug to expose some of the occurrences, and several hundred pounds of ore was taken out. No further work has since been attempted. The principal exposures are found in an area about 500 feet square. The chief manganese minerals are psilomelane and pyrolusite."

If the location shown by Stipp and others is correct, then it is possible that the mineralization might extend onto the reservation; if the Farnham and Stewart location and description are correct, then it is unlikely that the minerals would extend onto Indian land.

Nonmetallic Mineral Resources

General

Nonmetallic mineral resources consist of limestone, sandstone, tuff, gypsum, travertine, sand and gravel, and possibly fluorite. Only sand and gravel are known to have been produced. Guano (bat excrement) has been produced from a cave across the Colorado River.

Limestone

The mineral resource having the greatest potential for development over the long-term is high-calcium limestone. The material occurs in the Mississippian Redwall Limestone and is described by Twenter (1962, p. 13) as being 500 to 600 feet thick in the reservation area. The Redwall occurs both in the Grand Canyon area and along the southern border (Figure 4) where it forms exposures over several townships. The Redwall is quarried by Flintkote Corp. for the production of lime at Nelson about a mile from the reservation boundary. Flintkote reports that the material it is using is 98 percent $CaC0_3$. Redwall limestone analyzed by the Arizona Department of Natural Resources contained 99 percent $CaC0_3$.

Limestone with a $CaC0_3$ content above 96 percent, or the derived product lime (CaO), is required for many products or processes (Figure 9). Other uses exist for raw limestone, including metallurgical flux and manufacture of calcium, portland cement, and glass; as whiting in paints, rubber, and rubber dyes; and in manufacturing or processing fabrics, plastics, phonograph records, explosives, medicines, ink, glue, insecticides, and sugar (Key, 1965, p. 69-77). A recently developed use for limestone and lime is for cleaning sulfur and sulfur compounds from stack gases.

Lime containing small amounts of magnesium carbonate (dolomite) is more effective than limestone for cleaning sulfur from stack gases. The market for such a compound may increase over the next few years, but whether the increase will be large enough to support a plant producing material solely for that purpose is questionable.

The Redwall Limestone is a proven source of raw material for lime manufacture. The Flintkote Corp. recently completed a new 800-ton-per-day lime production facility at Nelson, Ariz., that uses this limestone. Other lime plants in the region include 8 in Arizona, 4 in Nevada, 15 in California, 5 in Utah, 1 in New Mexico, and 11 in Colorado. Among these are several captive plants owned by Great Western Sugar Corp., Kennecott Copper Corp., and other industries that require large quantities of lime in their manufacturing processes.

The Kaibab Limestone crops out over a large area in the eastern part of the reservation. According to McKee (1938), the Kaibab contains between 50 and 90 percent $CaC0_3$. A $CaC0_3$ content below 95 percent does not qualify the material for high calcium uses, such as chemical or metallurgical stone, but it is suitable for use as crushed stone; some of the higher grade limestone might be suitable for cement manufacture under certain circumstances.

A large number of products or processes requiring calcium or calcium carbonate as a raw material are manufactured or used in the U.S. Probably the best chance for developing limestone on the Hualapai reservation appears to be in the manufacture of calcium products (products containing calcium carbonate, or lime) for the chemical industry, using the Redwall Limestone as raw material.

Sandstone

Sandstone suitable for crushed stone, flagstone, and dimension stone occurs in vast quantity.

Flagstone is produced by several companies near Seligman, about 30 miles east of Peach Springs, from the Coconino Sandstone. The Coconino Sandstone crops out in many places in the reservation. About 10 or 15 years ago the tribe invited a stone producer in Seligman to produce flagstone from the reservation.

Some difficulty apparently was encountered in moving equipment to the site and no stone was produced. However, according to Townsend (1961, p. 14), a market for Coconino sandstone exists throughout the United States, and he notes that the stone has been sold as far away as Alaska and Canada.

Gypsum

Massive gypsum occurs in the Toroweap Formation underlying the Kaibab Limestone (Twenter, 1962, p. 16), but little is known about the quality of the material.

Tuff

Volcanic tuff occurs at the head of Milkweed Canyon in secs. 30 and 31, T. 26 N., R. 13 W., and secs. 25 and 26, T. 26 N., R. 14 W. (Twenter, 1962, p. 22) (Figure 3). Tuff was used to some extent as a building stone during early Arizona history (Townsend, 1961, p. 25). The material is light in weight, easy to shape, and has good insulation qualities. Although it has not been used extensively during the past half century, a small market probably exists for the material. Twenter (1962) describes the tuff in Milkweed Canyon as relatively thick. No information is given on color or quality of the stone.

Sand and Gravel

Large quantities of sand and gravel occur but the material is being produced from only two of four locations on the reservation (Figure 7). Most current production is used to maintain roads on the reservation, but the State of Arizona Highway Department has one area leased until February 1978.

Sand and gravel resources are large enough to supply any foreseeable market on the reservation.

Travertine

Travertine, generally produced as decorative or facing stone, occurs in Quartermaster, Meriwitica, and Spencer Canyons (Figure 7). The deposits are about 400 feet thick and one-half mile wide (Twenter, 1962, p. 30-31), and are situated 2,000 to 2,500 feet below the canyon rim. Access to them would be difficult and expensive.

A tremendous quantity of the material nevertheless is available, and it may prove to be a valuable future resource.

Fluorite

Fluorite has not been reported to occur on the reservation. However, a fluorite deposit, the Blue Daisy, is listed in several publications as being located near the small area of Indian land at Valentine (Figure 7). E. A. Elevatorski (1971) describes the Blue Daisy deposit as a 4-foot vein of blue-green fluorite in faulted limestone located 4 miles east of Hackberry in T. 23 N., R. 13 W. This would place the deposit very near the reservation boundary. Whether the fluorite mineralization extends onto the reservation in unknown.

Guano

For many years guano was produced from a cave just north of the reservation. The material was moved by tramway from the cave across the river to a road on the reservation and trucked to market. The operation was shut down in the early 1960's, but reportedly thousands of tons of the material remain in the cave. Whether similar caves and deposits occur on the reservation side of the river is unknown.

Potential Mineral Resources

Nonmetallic minerals offer some potential resource for the Hualapai Tribe. The limestone quarry at Nelson has been active for many years and it should continue to produce. Quarries similar to that at Nelson might be developed. Other non-metal mineral commodities occur on the reservation and might become resources. In probable order of importance these are: flagstone and building stone, and sand and gravel.

Uranium-vanadium-copper deposits of strati-form nature are a potential in the sandstone of the Toroweap Formation, the Hermit Shale and the Supai Group.

RECOMMENDATIONS FOR FURTHER WORK

1. Encourage continued exploration for economic uranium deposits.
2. Perform a market study to determine whether a market exists or could be developed for high calcium limestone, dimension sandstone, tuff, and travertine on the reservation.

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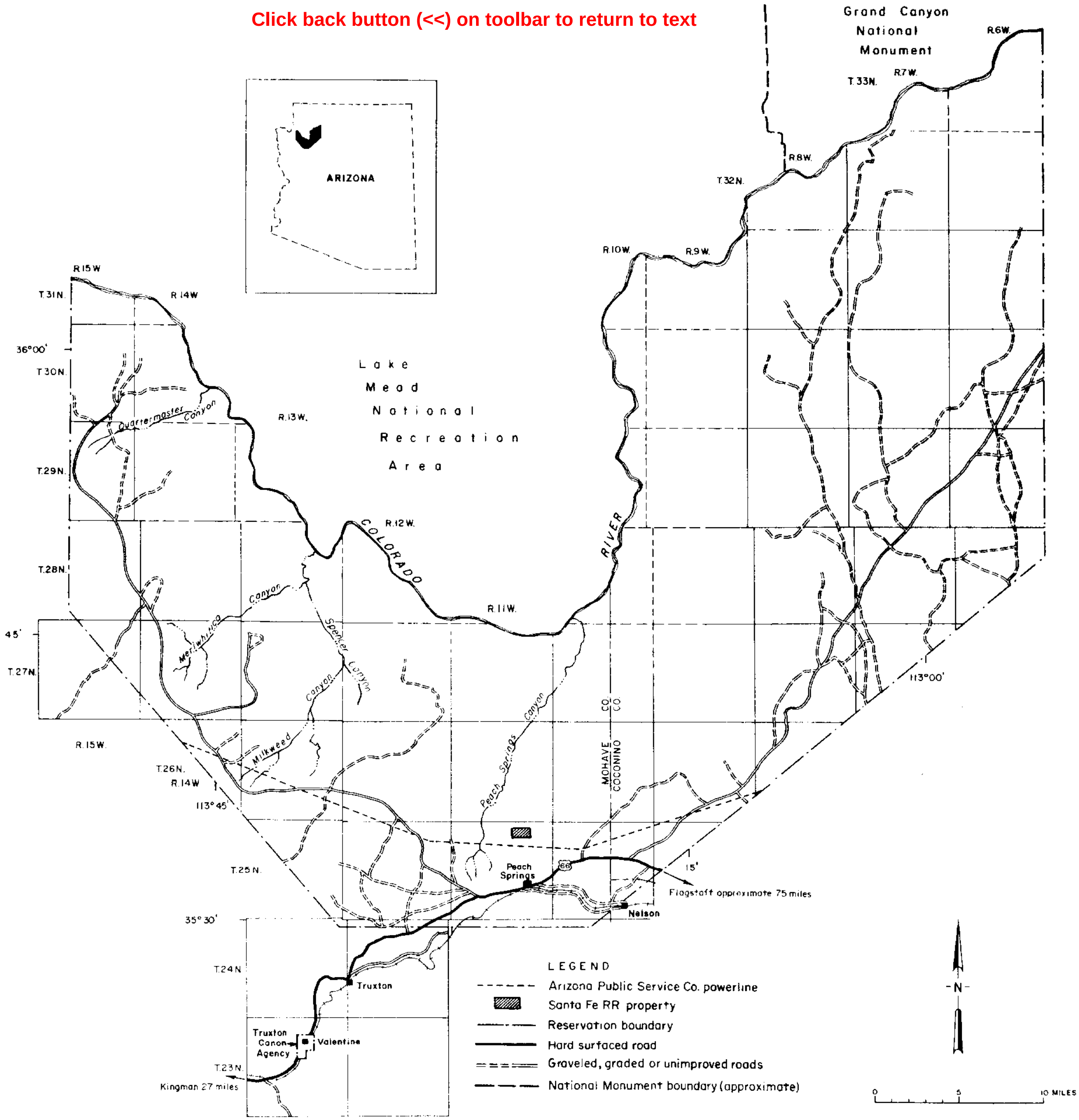

Figure 1. Index map showing infrastructure on Hualapai Indian Reservation.

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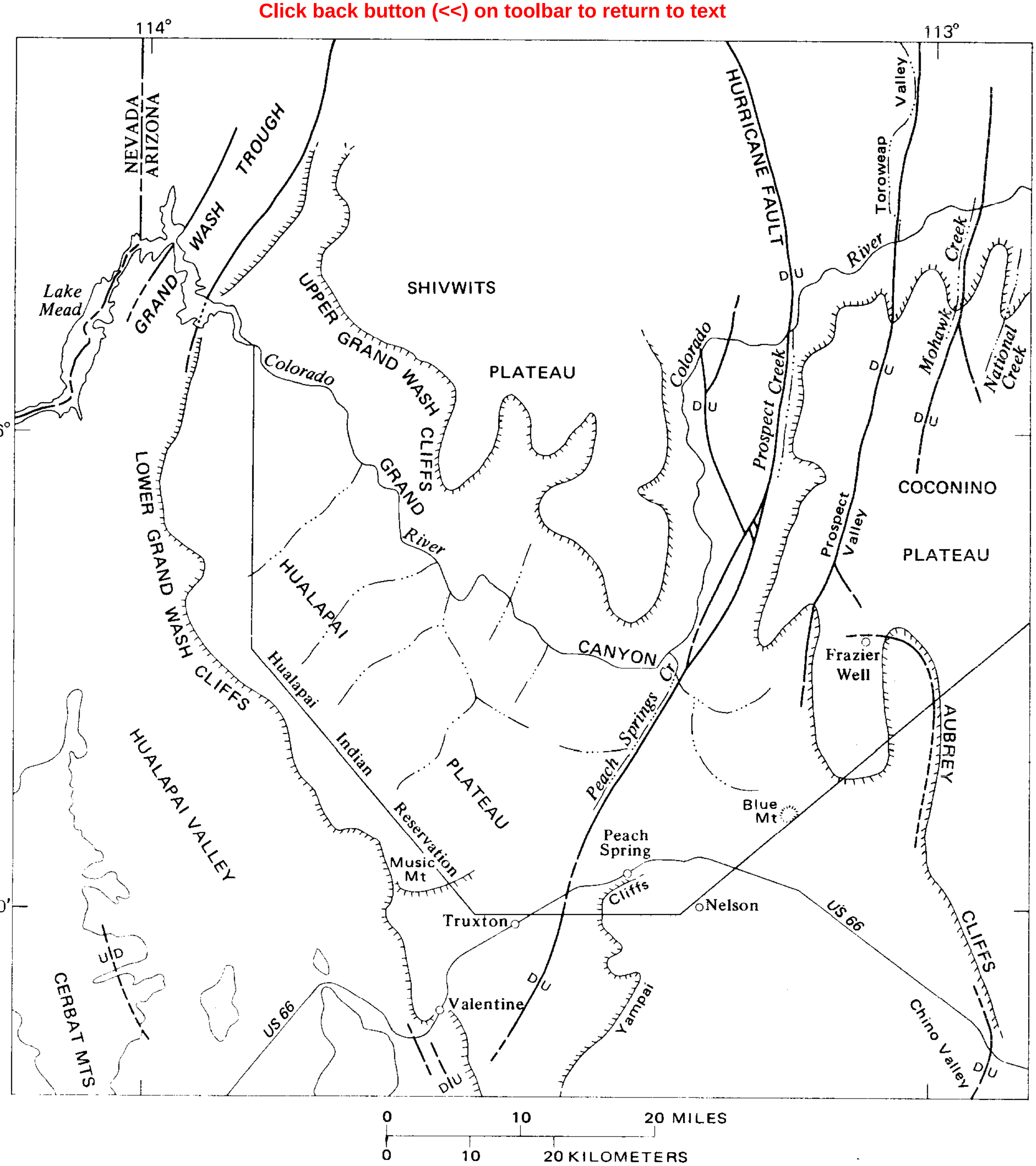

Figure 2. Map showing physiographic features and major of the Hualapai Indian Reservation.

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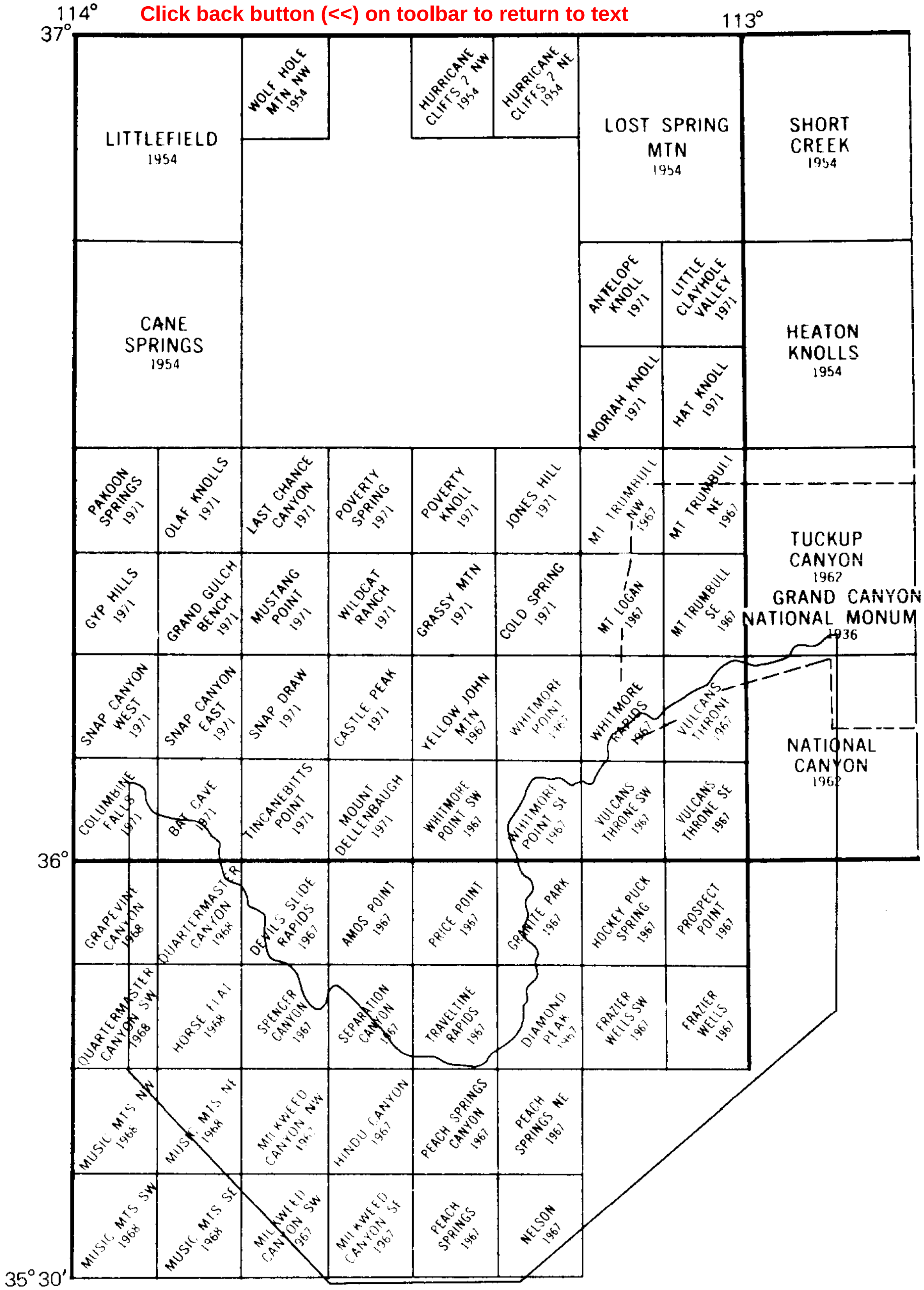

Figure 3. Index of topographic maps available for the Hualapai Indian Reservation.

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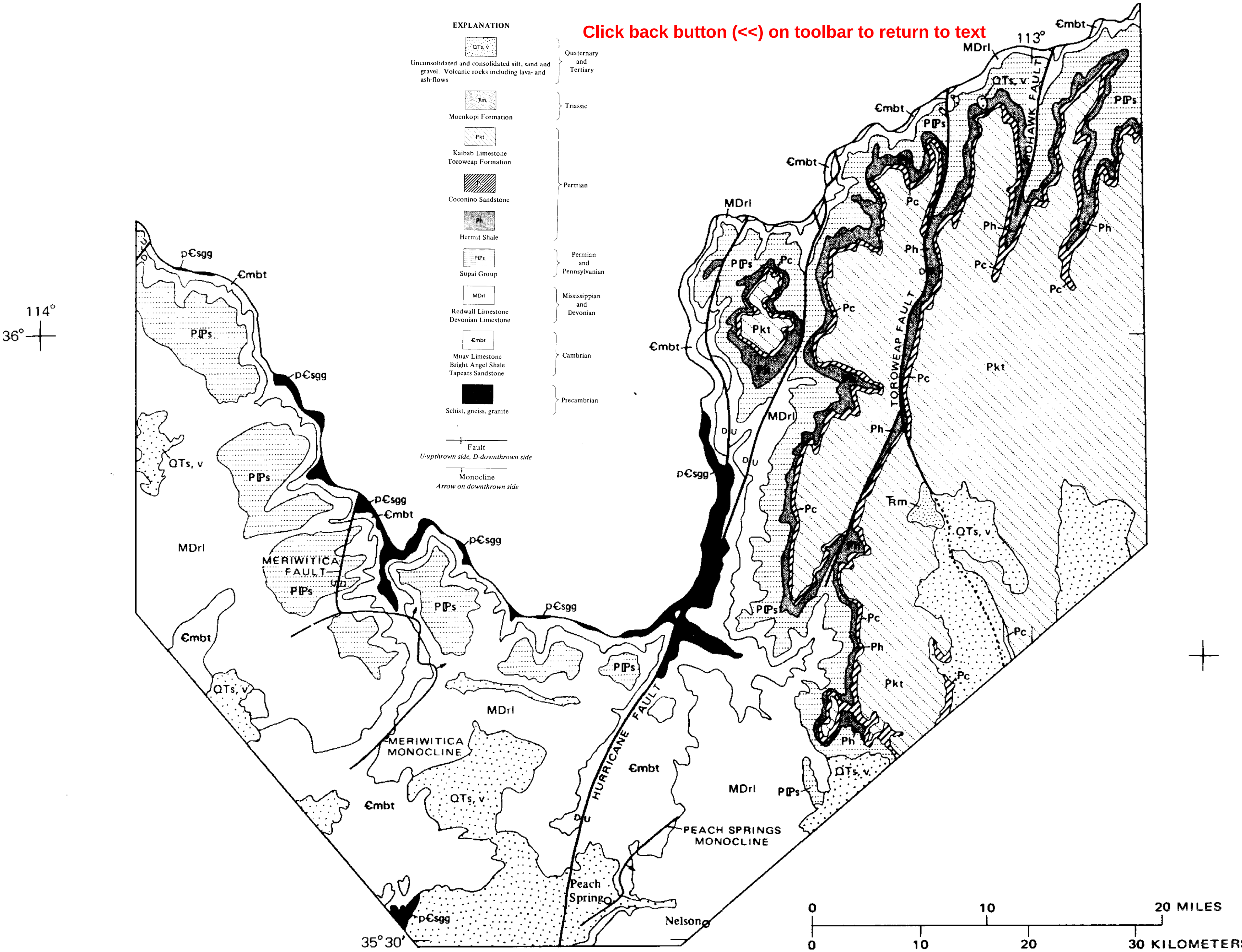

Figure 4. Geologic map of the Hualapai Indian Reservation (from State Geologic map of Arizona).

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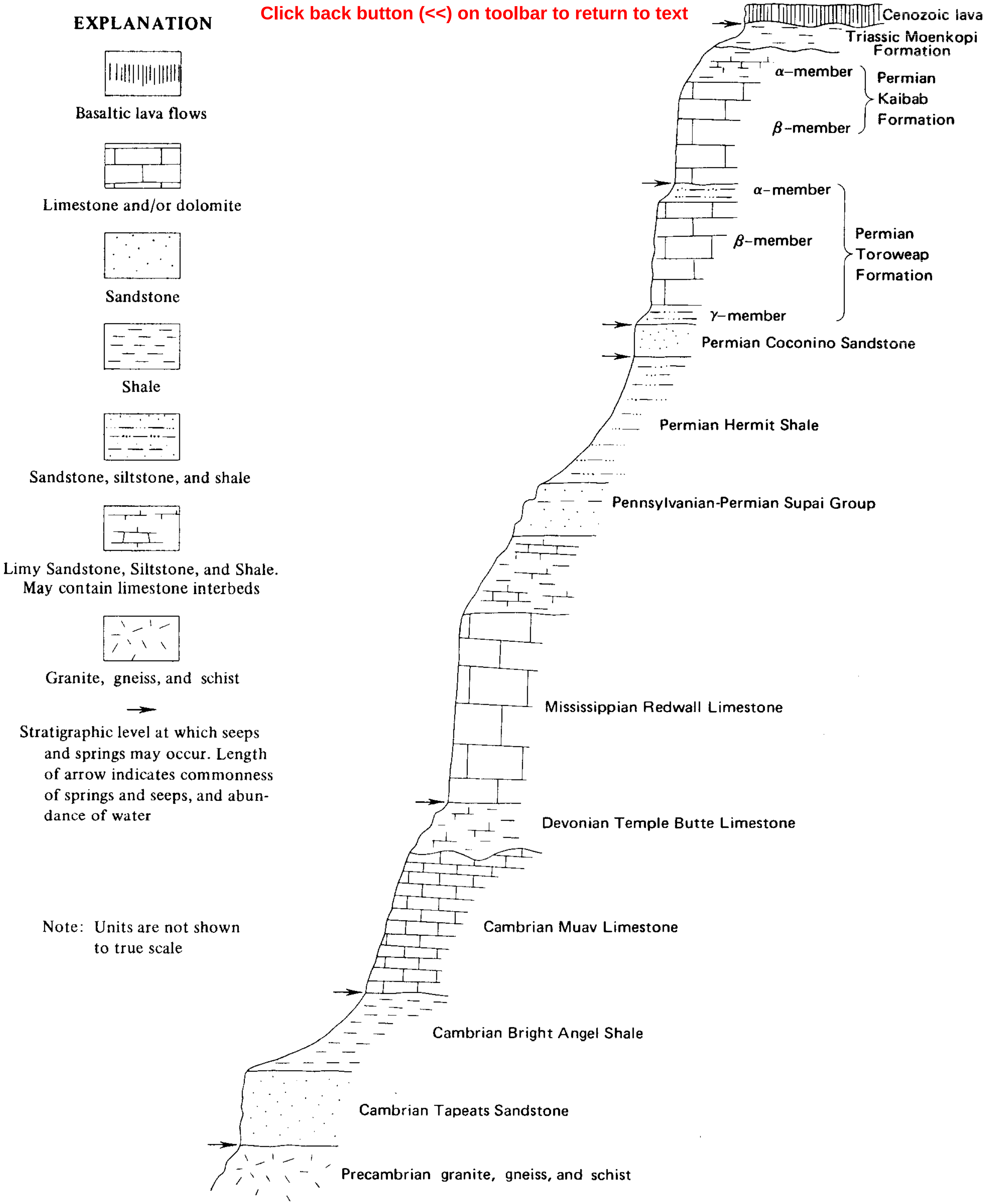

Figure 5. Diagrammatic stratigraphic section of the Grand Canyon region. Not drawn to scale (from Lucchitta, 1975).

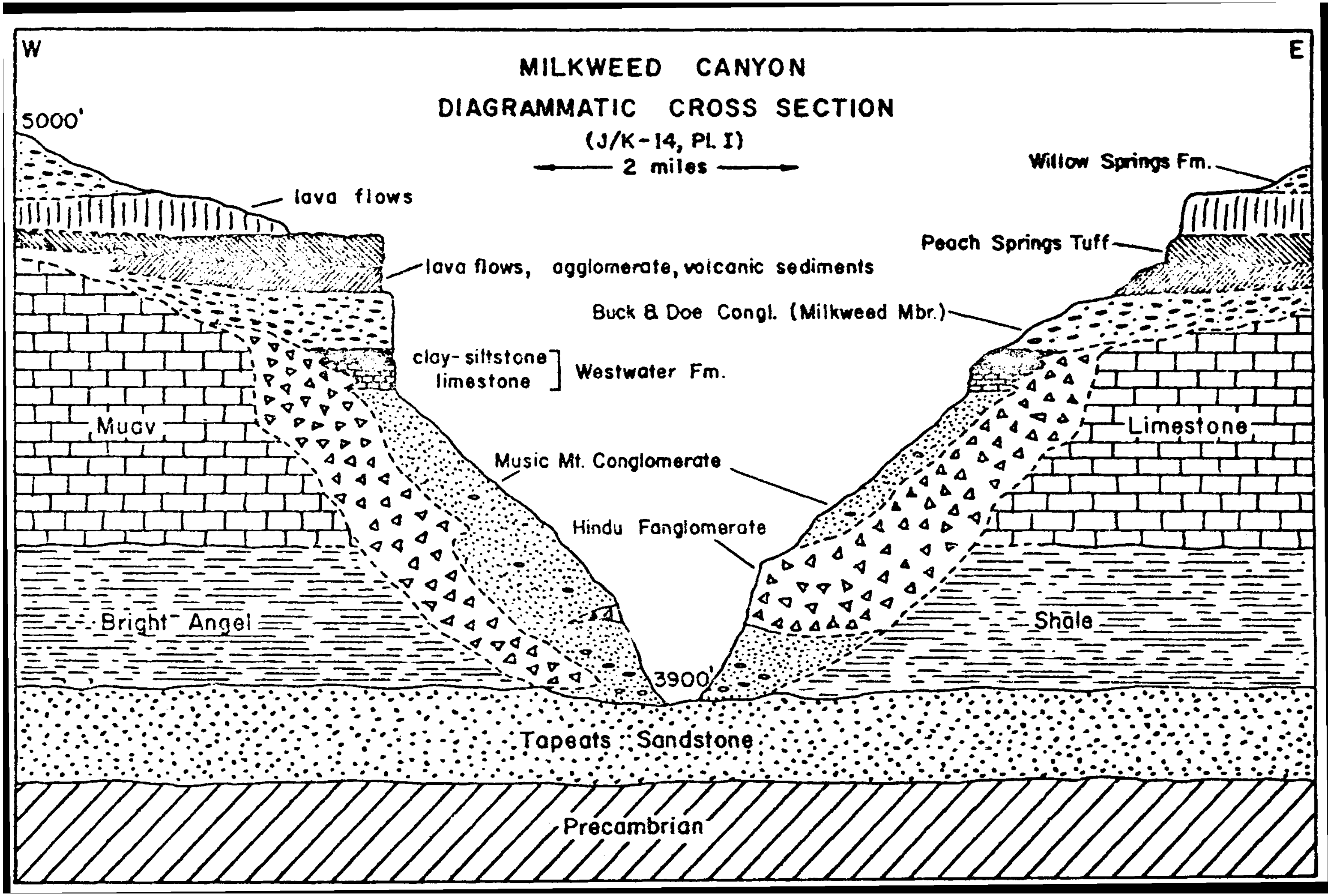

Figure 6. Diagrammatic cross section at Milkweed Canyon showing the relationship between the Cenozoic rock types and paleotopography cut in the Paleozoic strata (after Young, 1966)

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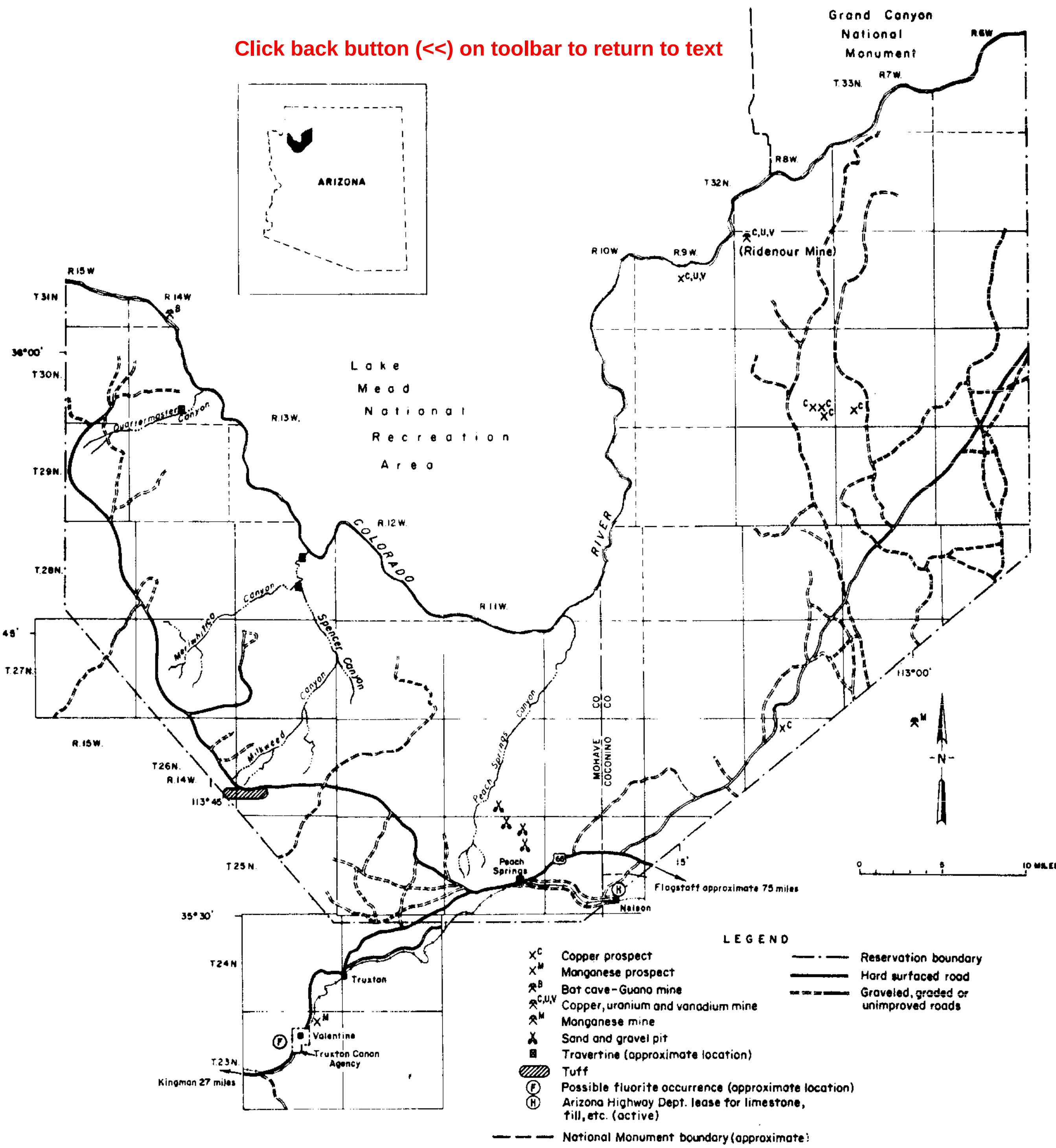

Figure 7. Map showing location of mineral resources, except fuels, on Hualapai Indian Reservation.

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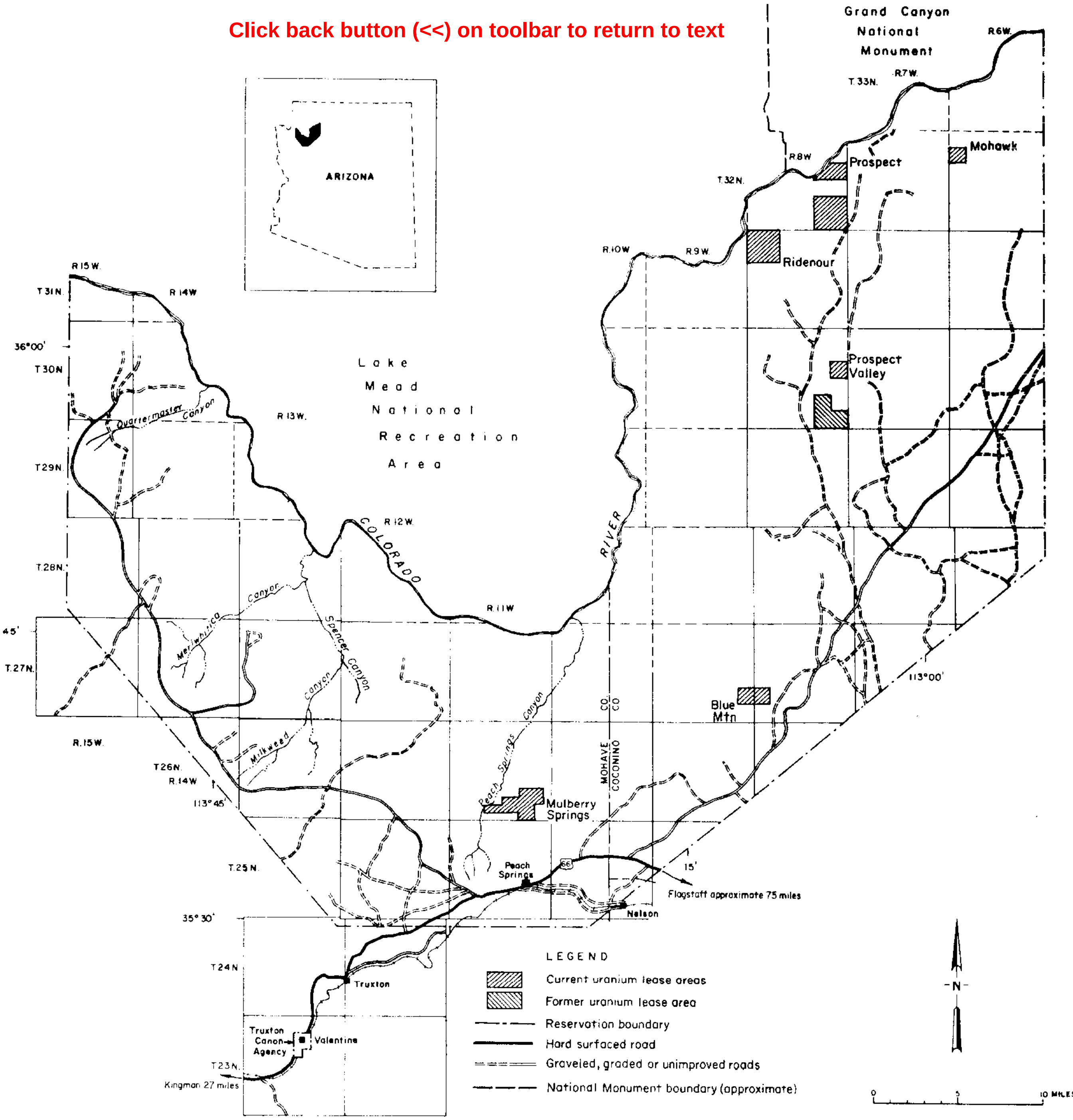

Figure 8. Map showing location of uranium leases, Hualapai Indian Reservation.

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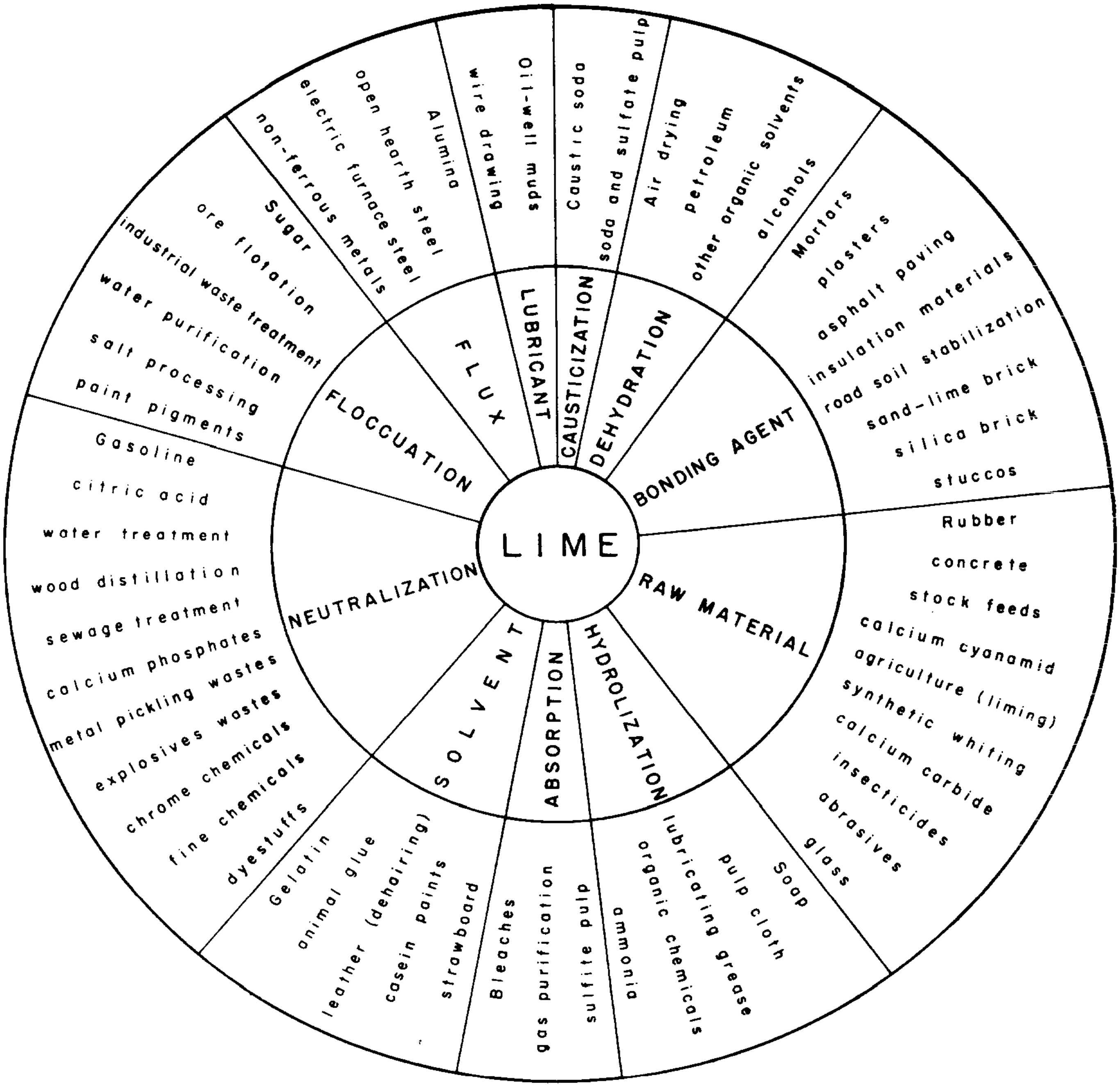

Figure 9. Diagram depicting uses of lime (from Key, 1965).